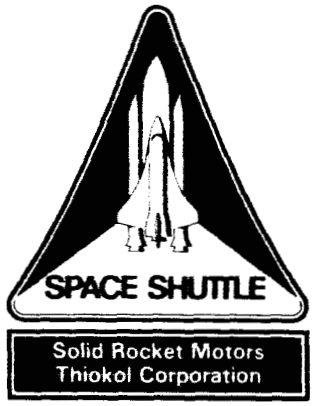
TWR-18697



Qualification of the RSRM Field Joint Pinhole Case-to-Insulation Bondline Inspection Using the Thiokol Corporation Ultrasonic RSRM Bondline Inspection System

Final Test Report

April 1990

Contract No. NAS8-30490
DR No. 5-3
WBS No. 4B102-10-10
ECS No. SS2412

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Publications No. 90510

Thiokol CORPORATION
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TWR-18897

Qualification of the RSRM Field Joint Pinhole Case-to-Insulation Bondline Inspection Using the Thiokol Corporation Ultrasonic RSRM Bondline Inspection System Final Test Report

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ABSTRACT

Qualification testing of Combustion Engineering's Amdata Intraspect/98 Data Acquisition and Imaging System that applies to the redesigned solid rocket motor field joint pinhole case-to-insulation bondline inspection was performed on 29 Jan 1990. Testing was performed at M-111, the Thiokol Corporation Inert Parts Preparation Building. The purpose of the inspection is to verify the integrity of the case-to-insulation bondline located beneath field joint clevis pinholes.

The pinhole scanner was first calibrated on the clevis ultrasonic calibration standard, then used to scan a 30-deg area (16 pinholes) of a clevis field joint, and then rechecked to ensure that the calibration settings did not change during the case scan. This procedure was successfully performed five times over the same 30 deg of the clevis joint to qualify the unbond detection capability of the pinhole scanner.

CONTENTS

FIGURES

ACRONYMS

KSC	Kennedy Space Center
NBR	nitrile butadiene rubber
RF	radio frequency
RSRM	redesigned solid rocket motor
URBIS	ultrasonic RSRM bondline inspection system

1

INTRODUCTION

This report presents the procedures, performance, and results of the qualification test for Combustion Engineering's Amdata Intraspect/98 Data Acquisition and Imaging System that apply to the redesigned solid rocket motor (RSRM) field joint pinhole case-to-insulation bondline inspection. The purpose of the inspection is to verify the integrity of the case-to-insulation bondline located beneath the field joint clevis pinholes. The inspection is performed at Thiokol Corporation's Utah Space Operations facility and again at Kennedy Space Center (KSC). The Intraspect/98 system is referred to as the Thiokol Corporation Ultrasonic RSRM Bondline Inspection System (URBIS) (C77-0479).

Testing was conducted in accordance with CTP-0087, Qualification Plan for the Ultrasonic Inspection of the RSRM Field Joint Pinhole Case/Insulation Bondline Utilizing the Thiokol Corporation Ultrasonic RSRM Bondline Inspection System. Testing was performed on 29 Jan 1990 at M-111, Thiokol's Inert Parts Preparation Building.

The URBIS functions by transmitting ultrasonic signals (pulse-echo) from the transducer surface to the case surface through a liquid couplant. A return signal is then received by the transducer. This return signal is amplified, filtered, digitized, and processed for display. During an inspection, a well-bonded case-to-insulation interface will reflect a small signal, while an air-backed unbonded region will reflect a larger signal.

Qualification testing of the URBIS components that are generic to all inspections (capture feature, clevis, pinholes and membrane) has been performed under CTP-0100 and is documented in TWR-18894. It is recommended that these documents and CTP-0087 be referred to for additional explanation of URBIS components and test procedures.

1.1 TEST ARTICLE DESCRIPTION

The pinhole scanner consists of an ultrasonic transducer that is directly mounted to a 1.75-in.-long plastic fixture (delay line) which holds the transducer in place (Figures 1 and 2). The plastic fixture has an integrated couplant feeder line that ensures an even distribution of couplant across the base of each pinhole. Couplant is used to provide a conductive interface between the transducer and the RSRM case. The 1/3-in.-diameter transducer has a center frequency of 5.0 MHz. The plastic fixture can rotate the transducer 360 deg while in contact with the pinhole surface. This rotation allows for detection of partial air-backed unbonds behind the pinholes. The pinhole scanner interfaces directly with the URBIS (C77-0479). The URBIS was assembled under 2U129431.

Testing was performed on the RSRM Flight 13A aft center insulated segment (P/N 1U76667-01, S/N 0000030). A calibration standard consisting of a section of RSRM case (clevis joint) with intentional case-to-insulation unbonds was used to calibrate the pinhole scanner/URBIS. The calibration standard was assembled under 2U129702 and is shown in Figure 3.

A detailed configuration of the generic URBIS components (Amdata Intraspect 98/Data Acquisition and Imaging System) used in association with the URBIS pinhole case-to-insulation bondline inspection qualification is documented in CTP-0100.

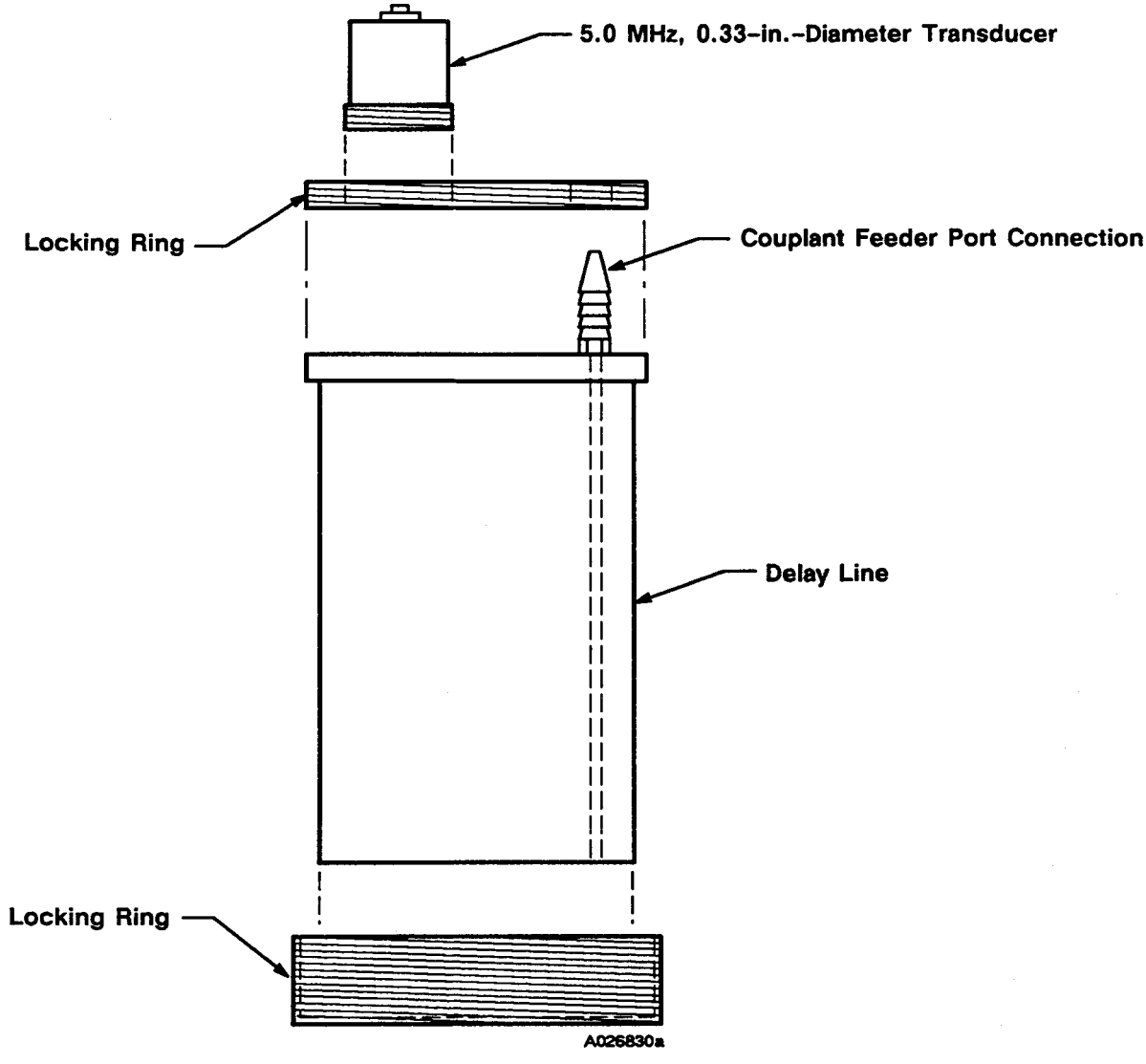
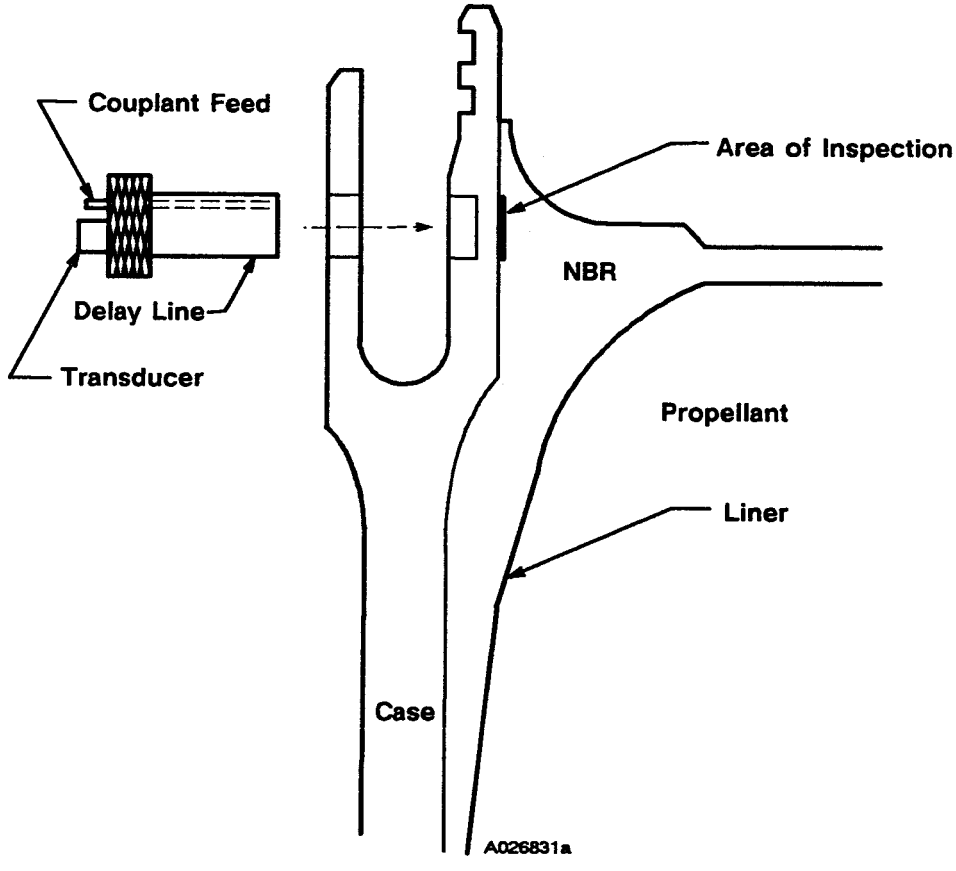
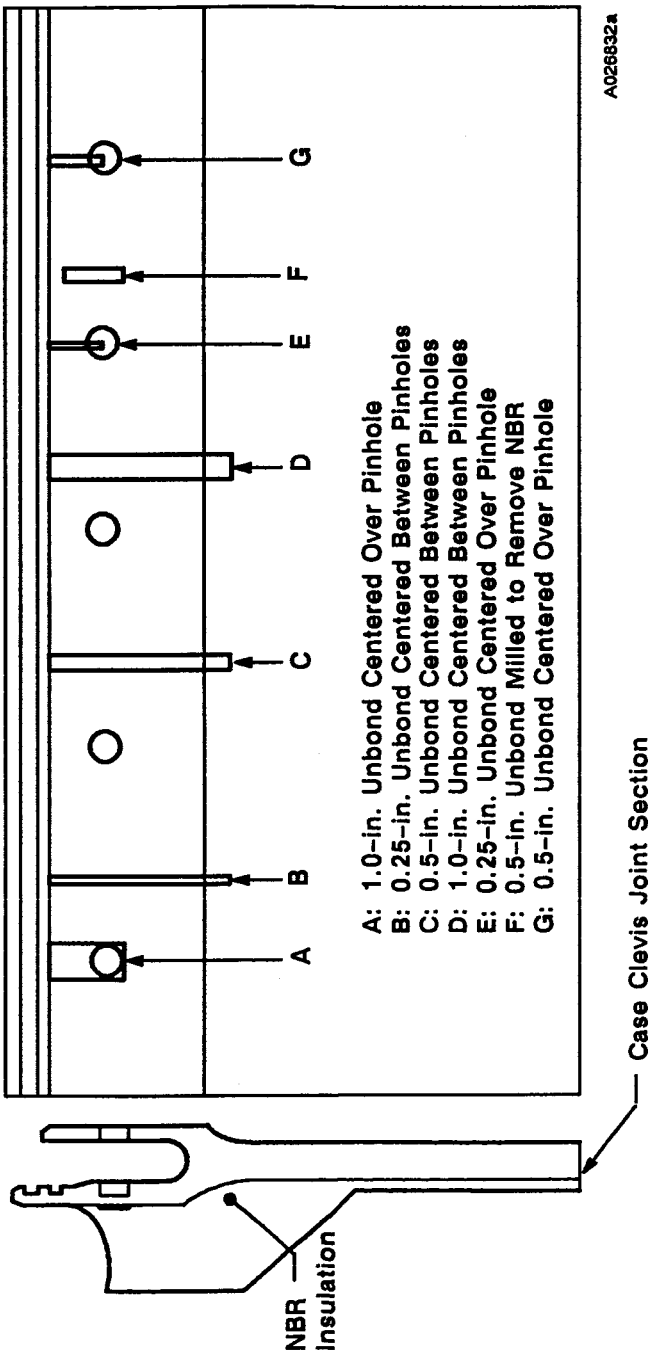


Figure 1. Pinhole Scanner



Note: Not to scale

Figure 2. Pinhole Scanner Inspection Area



Note: Not to scale

Figure 3. Unbond Diagram for Clevis/Pinhole Ultrasonic Calibration Standard (2U129702)

2

OBJECTIVES

The objectives of CTP-0087 were intended to qualify the tooling and techniques used in the RSRM pinhole case-to-insulation bondline inspection. The objectives were:

a. Verify that the ultrasonic inspection kit has the capability of detecting 1.0 by 1.0-in. unbonded surfaces, which are not detectable by visual inspection (CDW2-3452, Para. 3.2.1.1).

b. Verify that the ultrasonic inspection kit interfaces with the field joint of the segment and requires no special tools for attachment and release (CDW2-3452, Para. 3.2.1.2).

c. Verify that the ultrasonic inspection kit can be transported (CDW2-3452, Para. 3.2.8).

3

EXECUTIVE SUMMARY

3.1 SUMMARY

This section contains an executive summary of the key results from test data evaluation. Additional information and details can be found in Section 6.

The pinhole scanner was calibrated on the clevis ultrasonic calibration standard, which had an intentional 1.0 by 1.0-in. case-to-insulation unbond directly beneath a pinhole. The scanner was also calibrated over a fully-bonded area directly beneath a pinhole. The pinhole scanner was then used to scan a 30-deg area (16 pinholes) of a clevis field joint. Calibration of the pinhole scanner was then rechecked on the calibration standard to ensure that the calibration settings did not change during the case scan. This procedure was successfully performed five times over the same 30 deg of the clevis joint to qualify the unbond detection capability of the pinhole scanner. No unbonds were detected on the case joint. The pinhole scanner successfully interfaced with the clevis field joint pinholes throughout the scanning procedure. During the test, the pinhole scanner and the clevis joint were not degraded.

3.2 CONCLUSIONS

The following columns list the conclusions as they relate specifically to the objectives. Additional information to support each conclusion can be found in Section 6.

Objective	CDW2-3452 Paragraph	Conclusion
a. Verify that the ultrasonic inspection kit has the capability of detecting 1.0 by 1.0-in. unbonded surfaces that are not detectable by visual inspection.	Para. 3.2.1.1., General Performance. This inspection tool provides a means of detecting subsurface bondline failures which are not detectable by visual inspection. (Compressed "kissing" unbonds are not detectable.) The ultrasonic tool shall have the capability of detecting unbonds of 1.0 by 1.0 inch. Use of this tool shall permit unbonds to be detected and repaired before stacking. Use of the inspection kit shall not affect the reusability requirements for the case segment and associated equipment denoted in CPW1-3600, Table IV.	*Verified.* The pinhole scanner was calibrated over an intentional 1.0 by 1.0-in. unbond, then used to scan 16 pinholes of a case joint, and then checked for calibration accuracy. This procedure was successfully performed five times. This test qualified the unbond detection capability of the pinhole scanner/URBIS.
b. Verify that the ultrasonic inspection kit interfaces with the field joint of the segment and requires no special tools for attachment and release.	Para. 3.2.1.2, Installation Function. The ultrasonic case-to-insulation bondline inspection kit shall interface with the field joint of segment. Attachment and release of fixture shall be efficient and require no special tools.	*Verified.* The pinhole scanner successfully interfaced with the clevis field joint pinholes throughout the scanning procedure, without the aid of additional tools. During the test, the pinhole scanner and the clevis joint were not degraded.

c. Verify that the ultrasonic inspection kit can be transported.	Para. 3.2.8, Transportability/ Transportation. The case-to-insulation bondline inspection kit, ultrasonic, shall be capable of being handled and transported manually. The kit shall also be capable of being handled and transported by any suitable means during transportation to the launch site. The RSRM segment case-to-insulation bondline inspection kit, ultrasonic, shall be packaged in accordance with NHB 6000.1 to protect it from the shipping environment.	*Verified*. The complete URBIS is designed to be broken down into components which are placed in protective cases for transportability. This testing verified the transportability of the pinhole scanner/URBIS.

3.3 RECOMMENDATIONS

Based on the successful completion of testing under CTP-0087, the pinhole scanner/URBIS should be considered qualified for RSRM inspections at Thiokol Corporation's Utah Space Operations and at KSC.

4

INSTRUMENTATION

Test instruments were electrically zeroed and calibrated in accordance with MIL-STD-45662.

5

PHOTOGRAPHY

Still black and white photographs of the test setup were taken. Copies of the photographs taken (series No. 115650) are available from the Thiokol Corporation Photographic Services department.

6

RESULTS AND DISCUSSION

6.1 TEST ARTICLE COMPONENT DESCRIPTION

The following inspection components were used during this test:

Component	Part No.	Serial No.
URBIS	2U129431-01	S-A51855
Pinhole Scanner	PHRD-3702	
Ultrasonic Transducer	PHRD-3701	124183

Prior to testing, the URBIS used in conjunction with the pinhole inspection was qualified under CTP-0100. The URBIS qualification consisted of routine maintenance, calibration, and an evaluation of the performance of the system.

6.2 INSPECTION SCAN PARAMETERS

The scan parameter used during the calibration sequences and during the joint scan was the radio frequency (RF) waveform. This waveform presents the transducer response signal, in which larger amplitudes indicate unbonds. (Additional information on unbond detection is presented in CTP-0100.)

6.3 TEST DESCRIPTION, RESULTS, AND DISCUSSION

Qualification of the pinhole scanner and inspection technique consisted of the following three steps:

1. The pinhole scanner and the inspection technique were calibrated on the clevis ultrasonic calibration standard (P/N 2U129702), which contained an intentional 1.0 by 1.0-in. case-to-insulation unbond directly beneath a pinhole. The scanner and inspection technique were also calibrated over a fully-bonded area directly beneath a pinhole. This calibration, known as "calibration in," enabled operators to clearly distinguish the 1.0 by 1.0-in. unbond from the bonded regions.

2. The pinhole scanner was then used to scan a 30-deg area (16 pinholes) of the RSRM-13A aft center segment clevis field joint (P/N 1U76667-01, S/N 0000030). The center of the 30-deg arc was at the top dead center of the case joint to allow gravity-induced loads to assist in revealing potential unbonds.

3. Calibration of the pinhole scanner and technique (on the calibration standard) were repeated upon completion of case joint scanning. This calibration, known as "calibration out", ensured that the initial calibration settings did not change during the case scan.

The three stages of the pinhole scan sequence were successfully performed five times over the same 30 deg of the clevis joint to qualify the unbond detection capability of the pinhole scanner. No unbonds were detected on the case joint.

Photographic coverage of the qualification test is shown in Figures 4 through 9 (Photographs of the calibration out were not taken because this sequence is the same as the calibration-in sequence.)

The inspection results are presented in Figures 10 through 19. Each scan sequence run includes the bonded and unbonded RF waveform signal response for the calibration in and the calibration out. Figure 10 shows the RF waveform signal response for the run No. 1 calibration-in sequence. The measured pinhole bondline areas are shown in red, with unbonds represented by large waveform amplitudes. The case scan data for run No. 1 and all subsequent runs were identical to the calibration run over the bonded surface. Figure 11 shows the RF waveform signal response for the run No. 1 calibration-out sequence. Figures 12 through 19 present identical information for qualification runs 2 through 5. Measurement repeatability of the pinhole scanner/URBIS was demonstrated by the identical results from each test run.

The pinhole scanner successfully interfaced with the clevis field joint pinholes throughout the scanning procedure. Figure 9 shows the scanner/pinhole interface. During the test, the pinhole scanner and the clevis joint were not degraded.

The complete URBIS is designed to be broken down into components which are placed in protective cases for transportability. This testing verified the transportability of the pinhole scanner/URBIS.

N115650-13

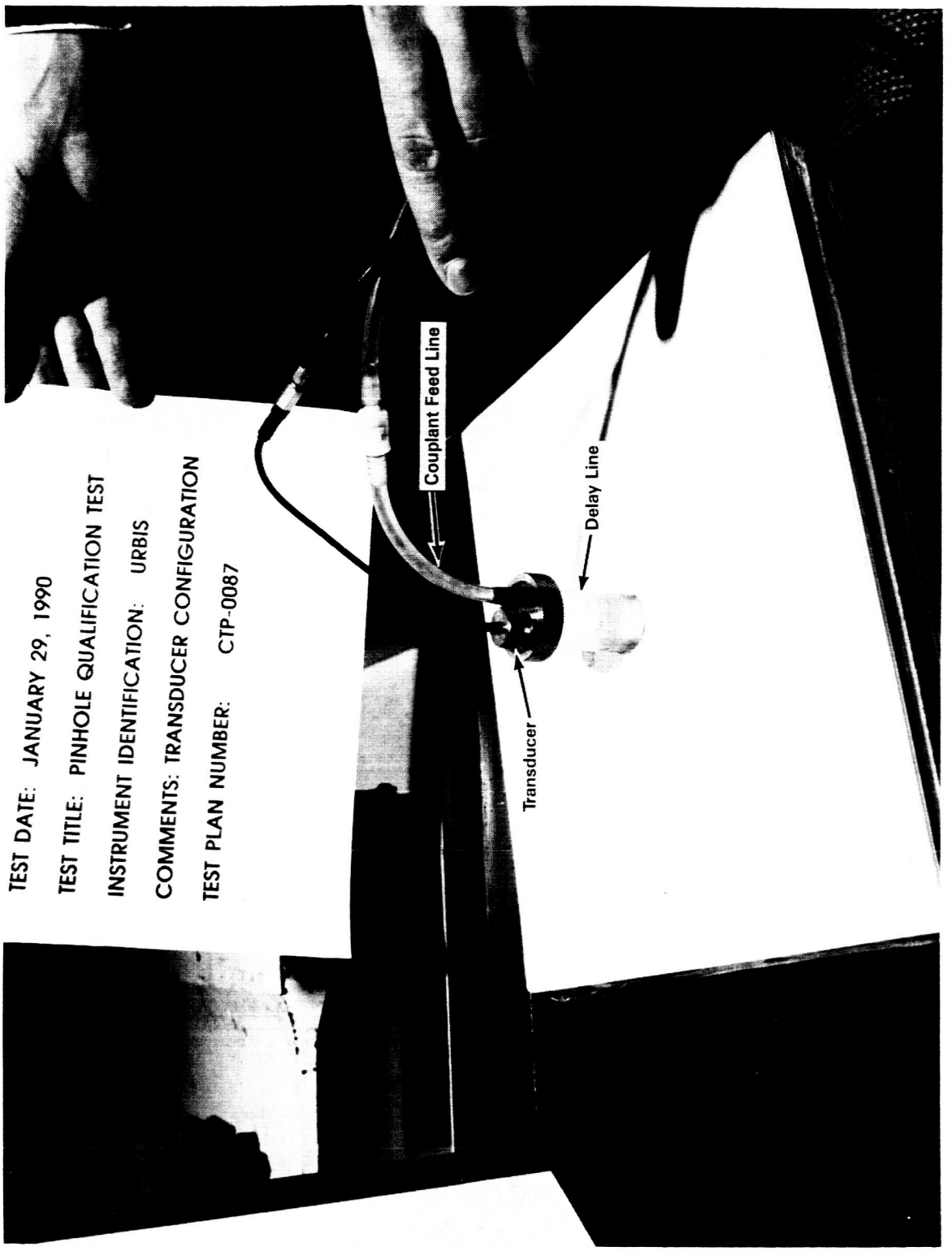


Figure 4. Pinhole Scanner

90510-2.11

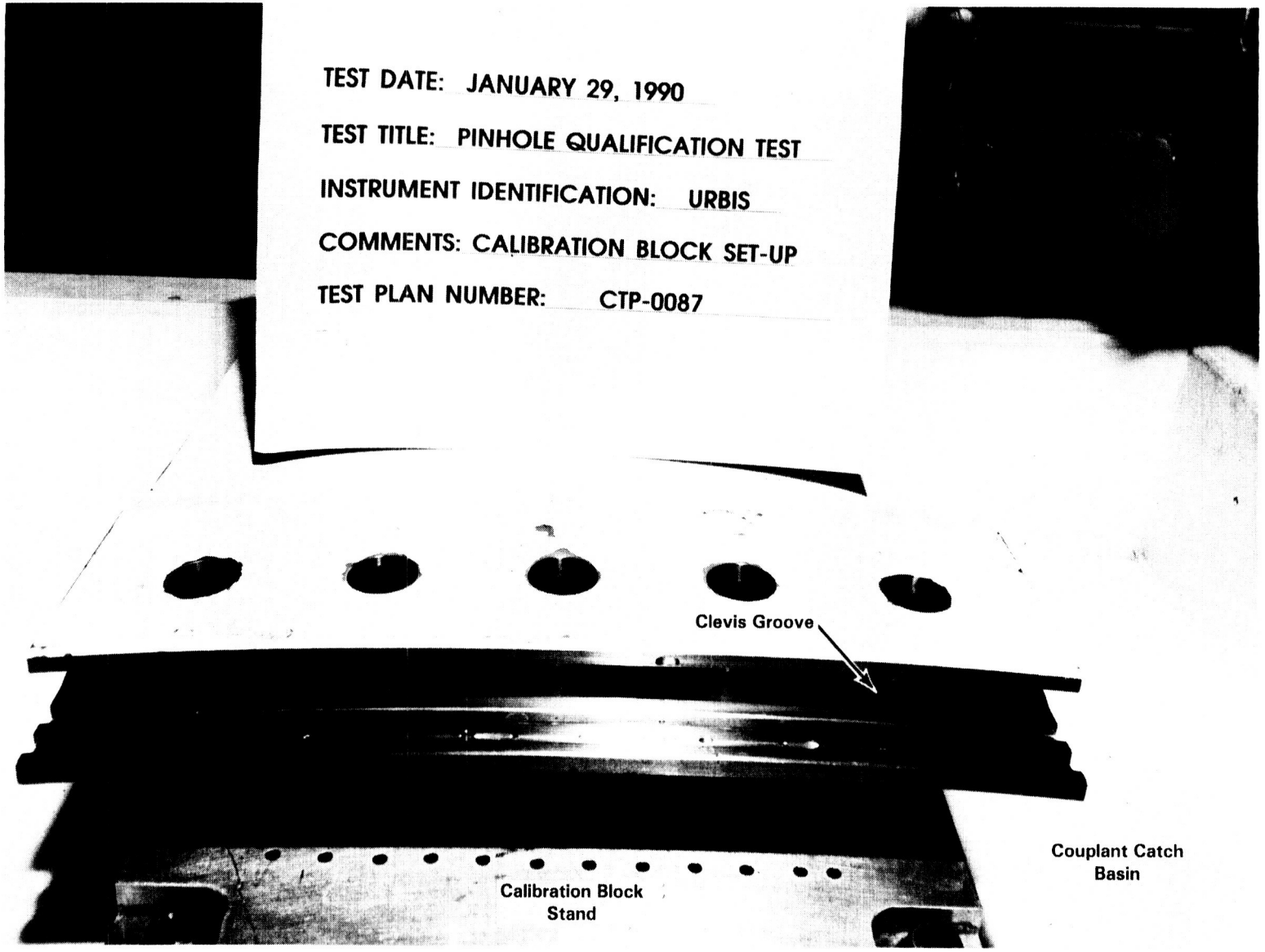


Figure 5. Calibration Standard Setup

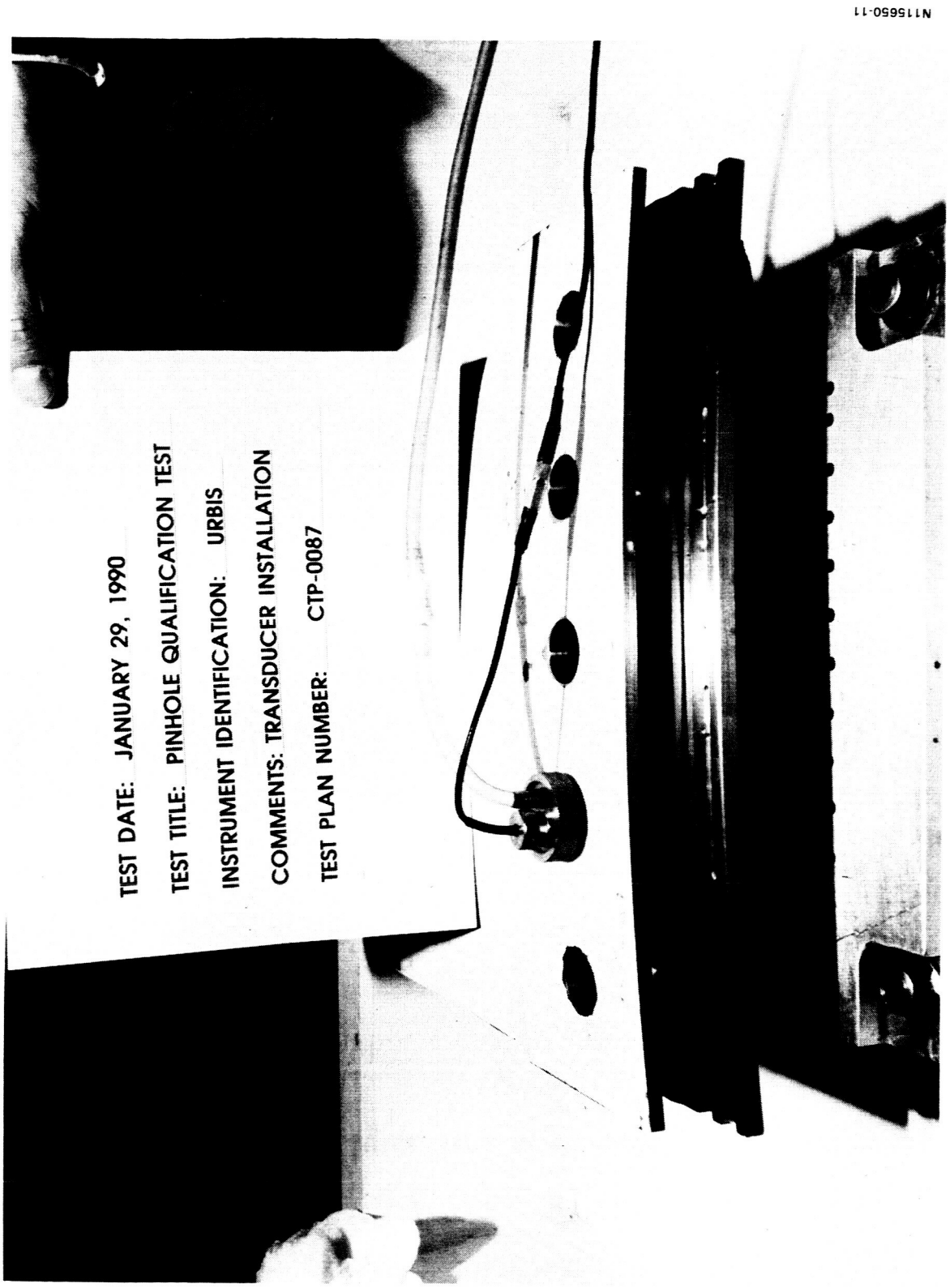


Figure 6. Pinhole Scanner Installed in Calibration Standard

90510-2.13

N115650-10

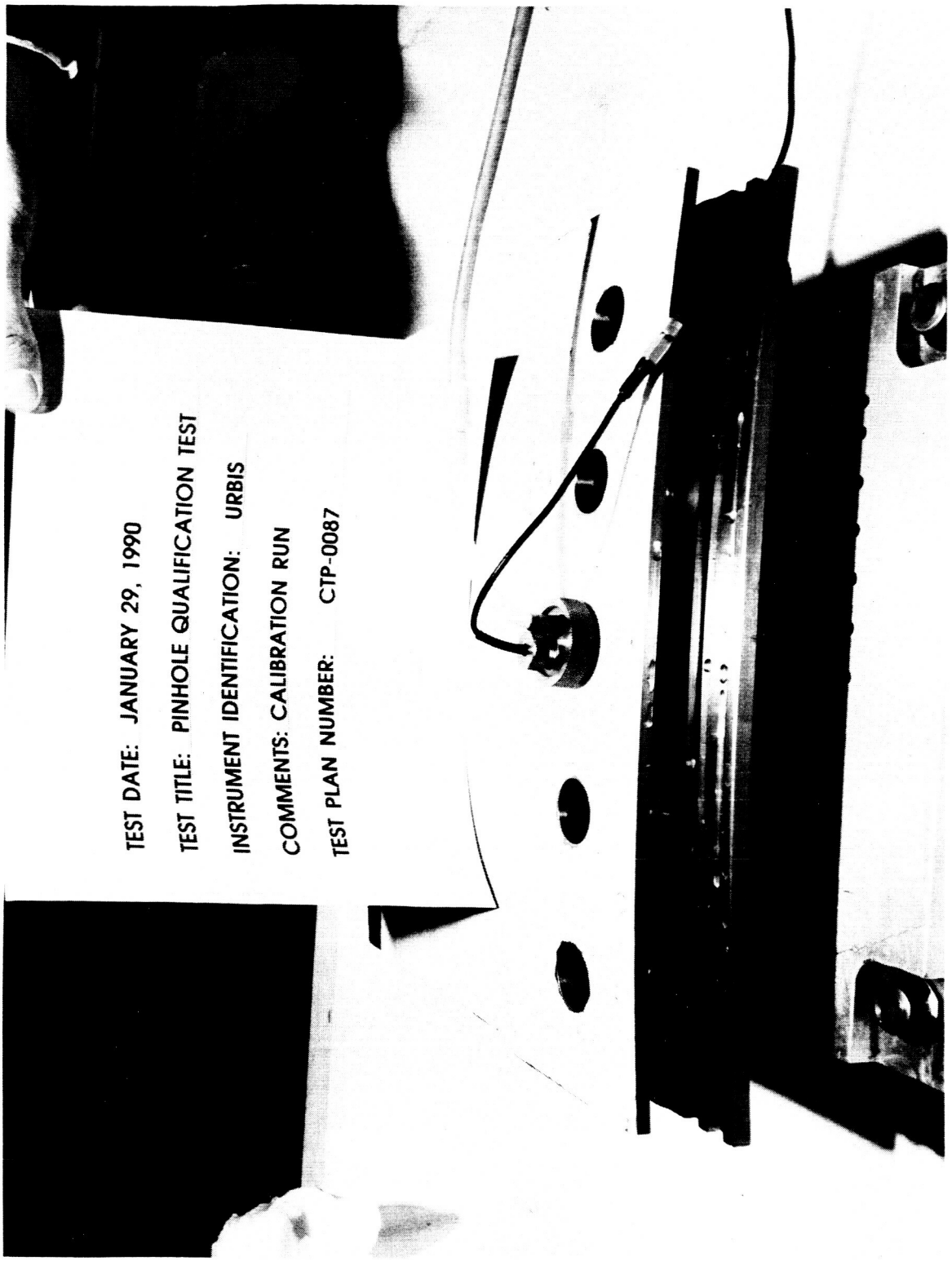


Figure 7. Calibration Run

90510-2.14

N115650-9

Figure 8. End Stand Being Positioned Next to Segment

90510-2.15

N115650-8

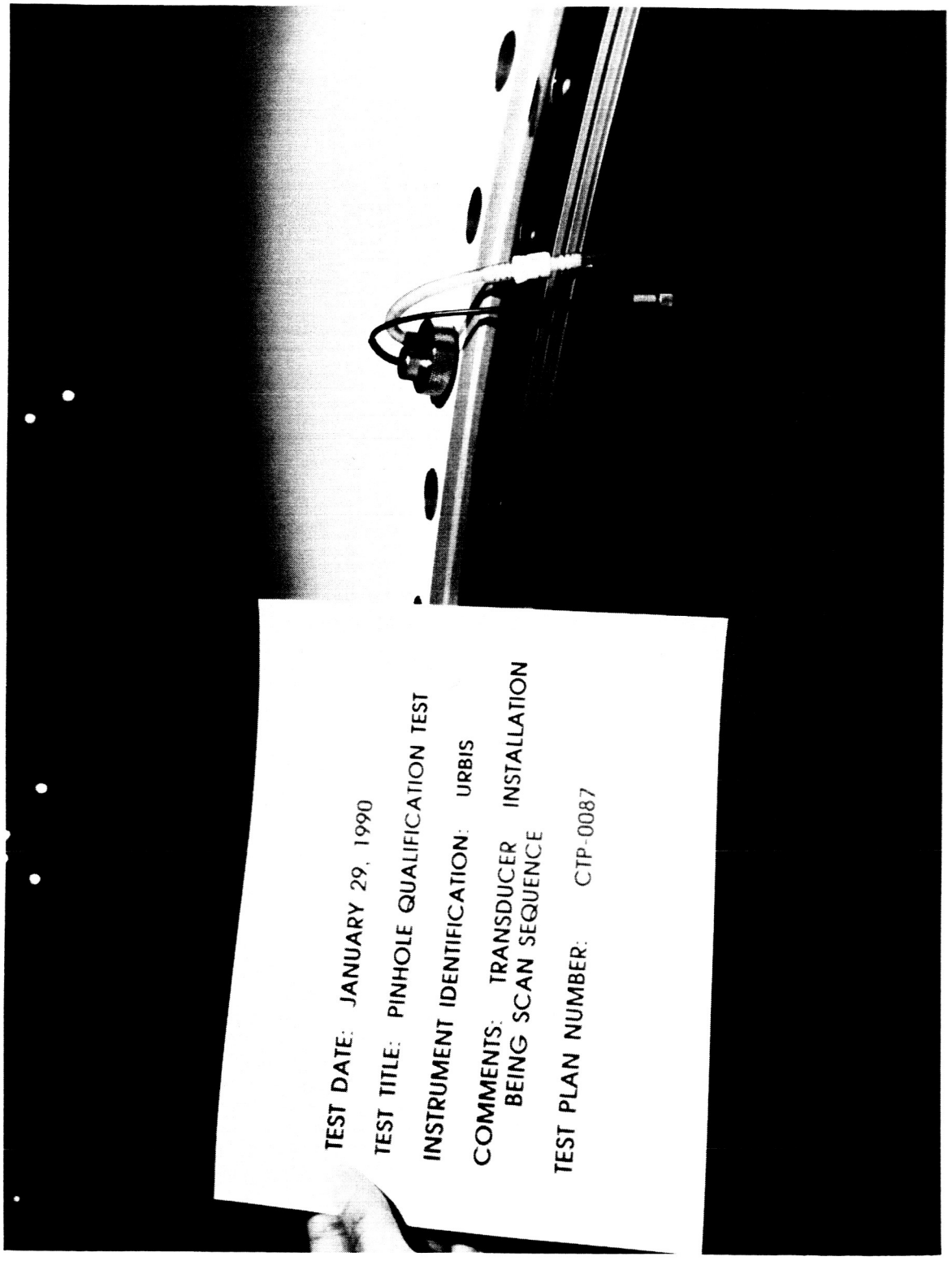
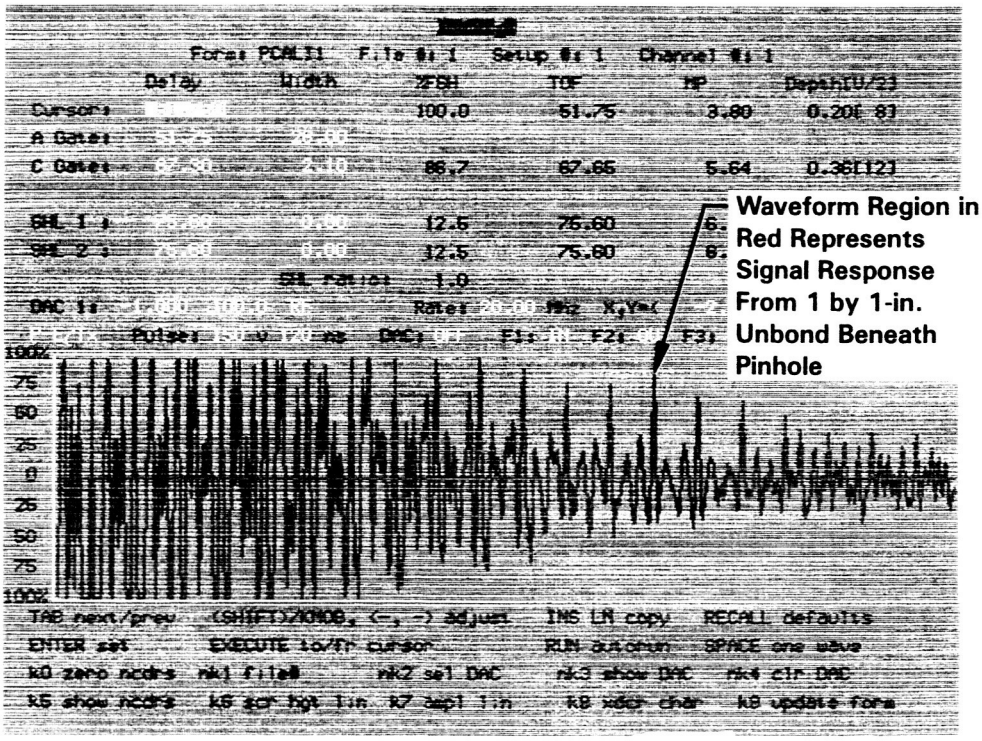
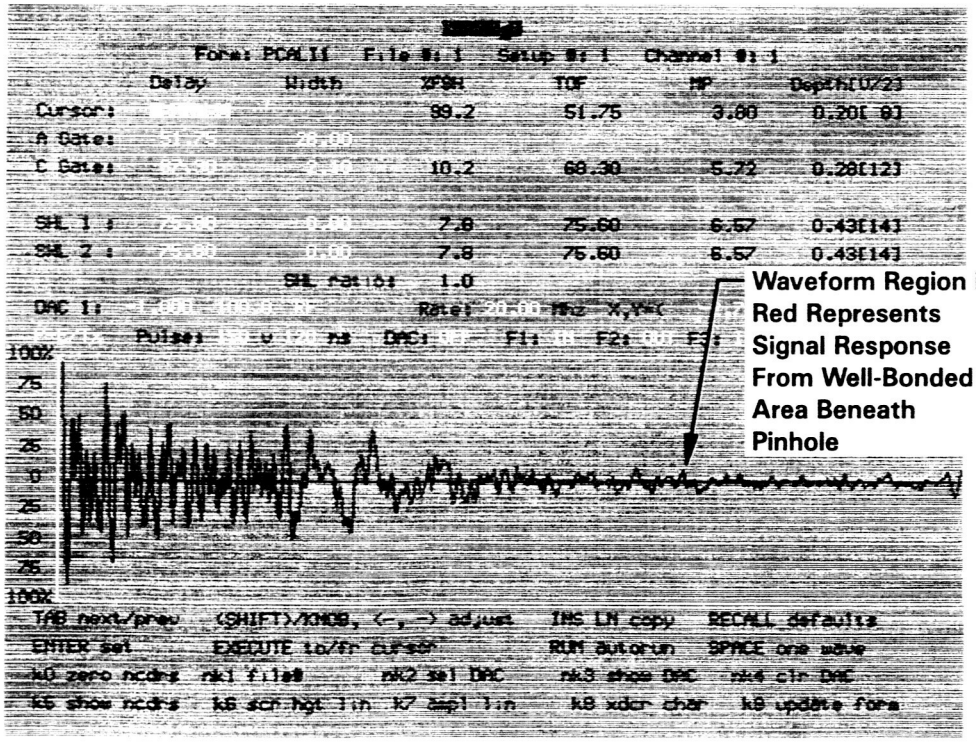


Figure 9. Pinhole Scanner Installed on Segment

90510-2.16

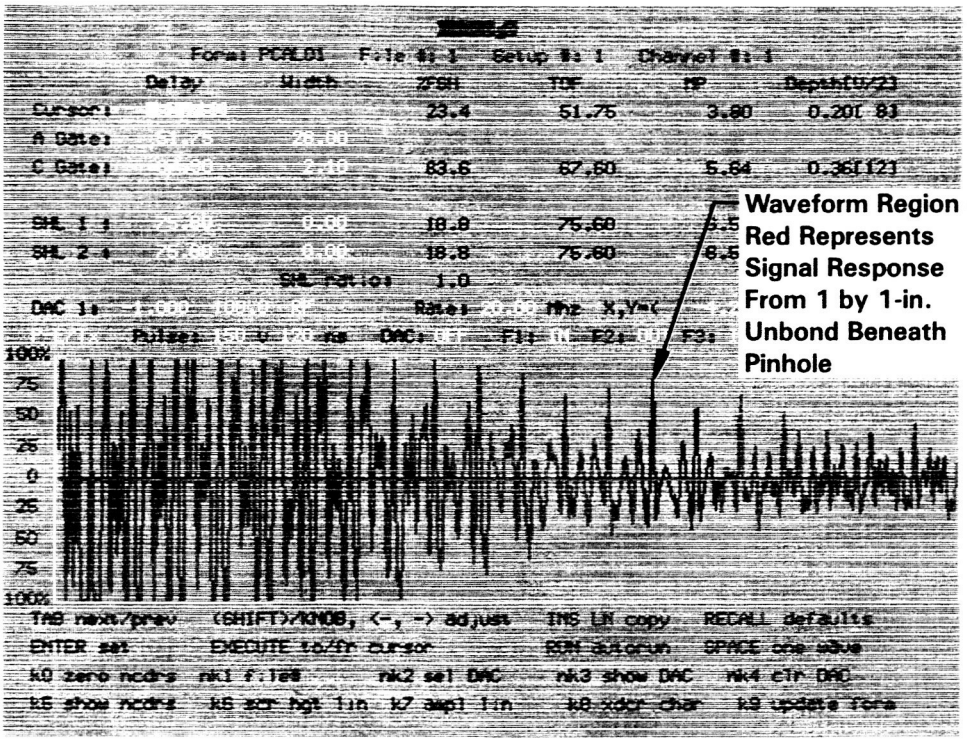


Unbond Signal Response

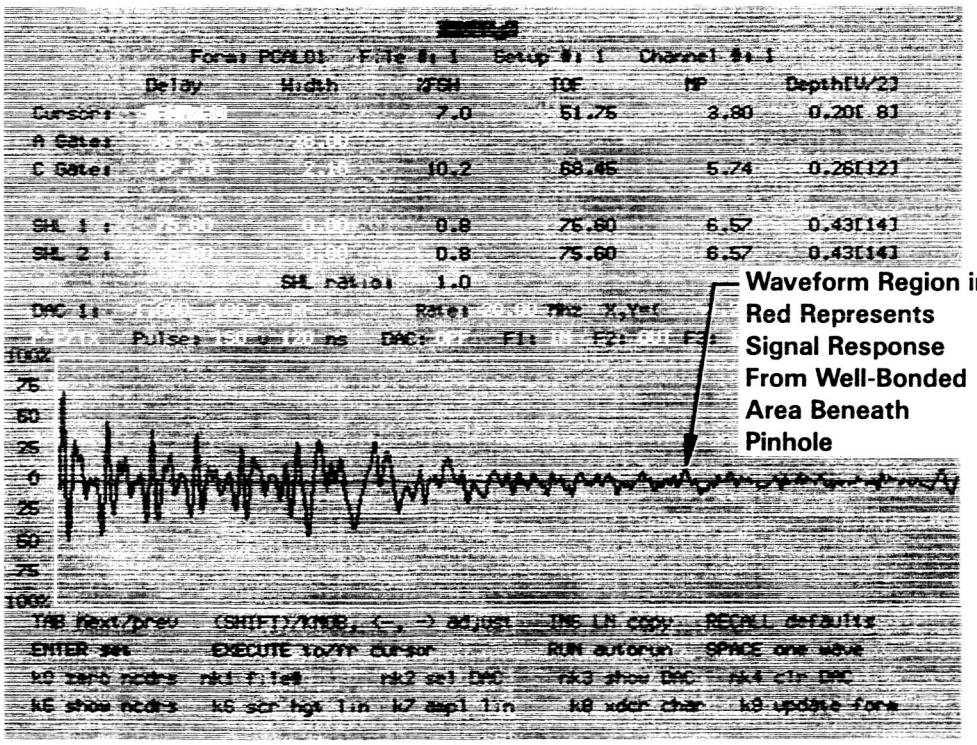


Bonded Signal Response

Figure 10. Calibration-in Sequence — Scan Run No. 1

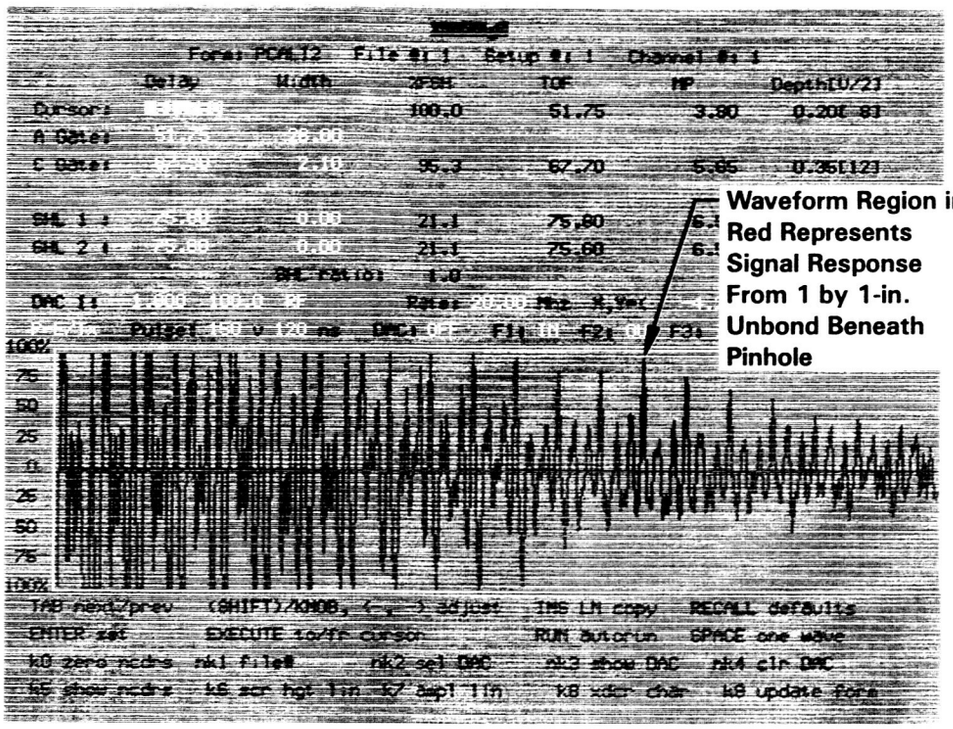


Unbond Signal Response

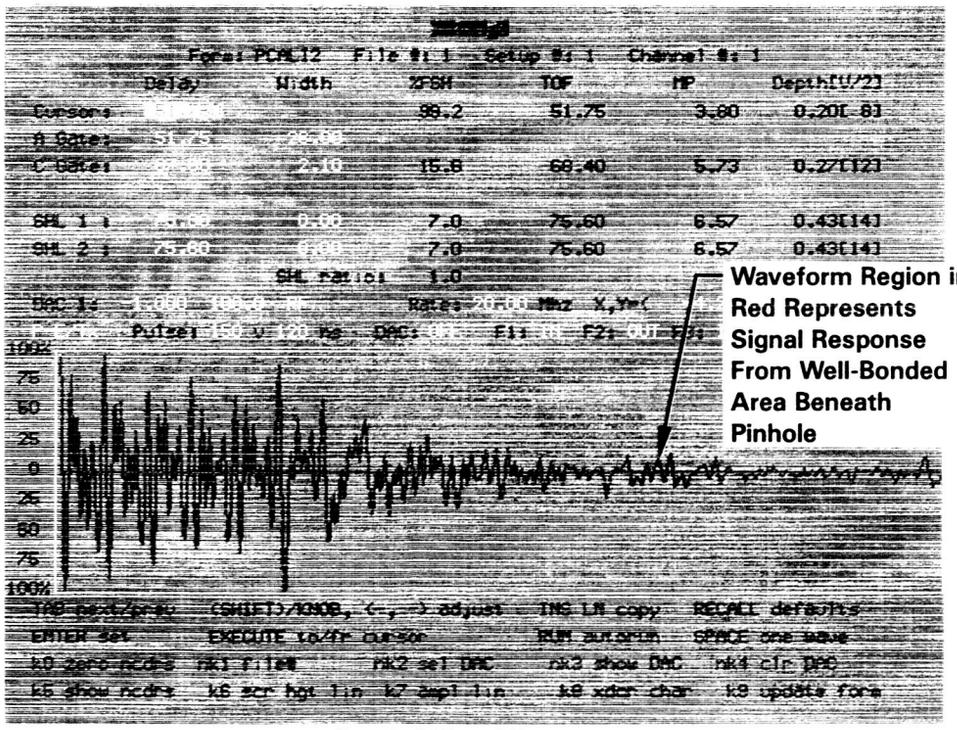


Bonded Signal Response

Figure 11. Calibration-out Sequence — Scan Run No. 1

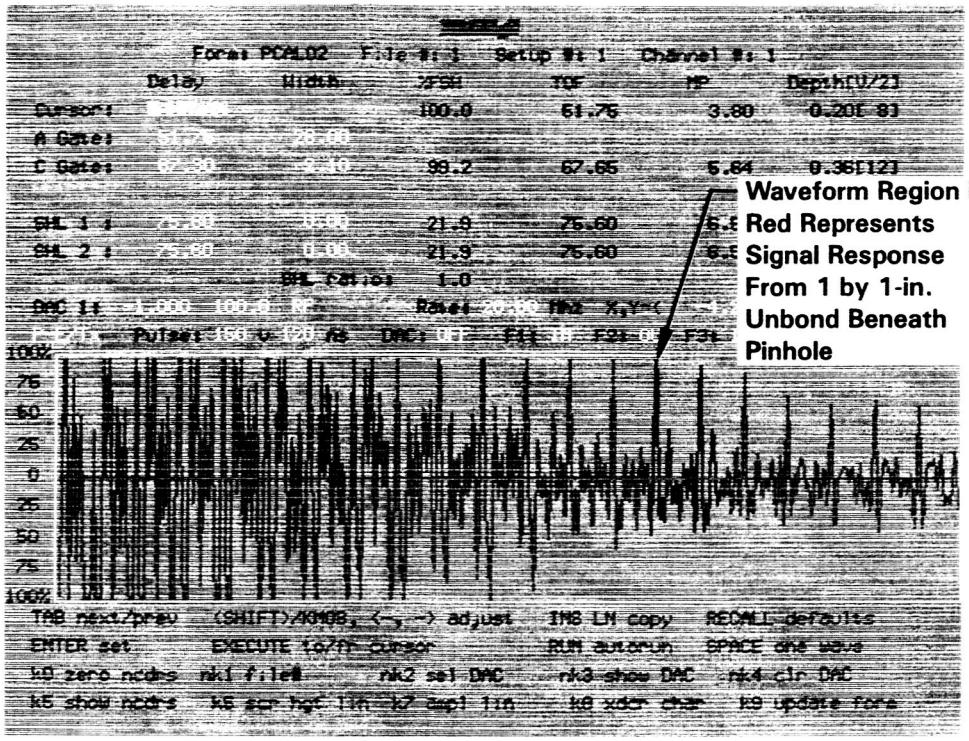


Unbond Signal Response

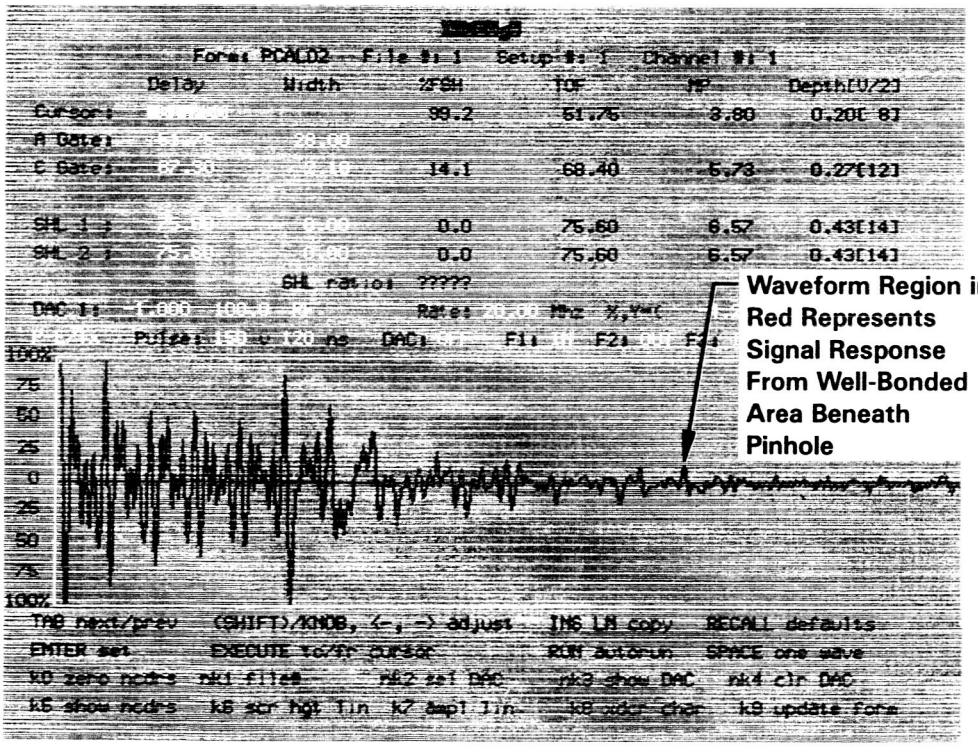


Bonded Signal Response

Figure 12. Calibration-in Sequence — Scan Run No. 2

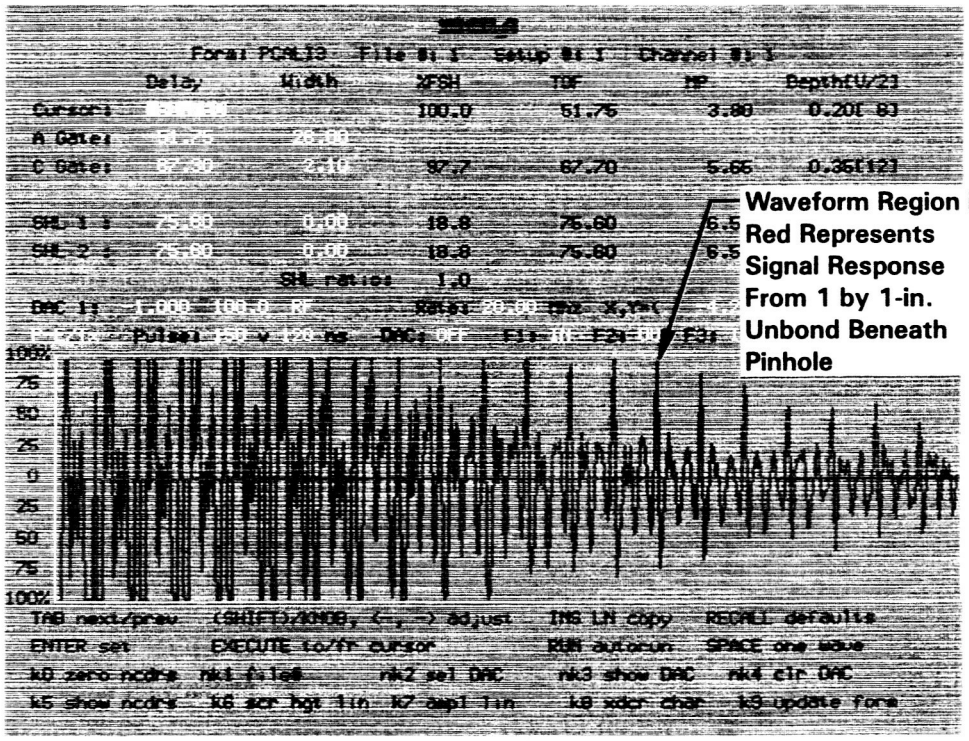


Unbond Signal Response

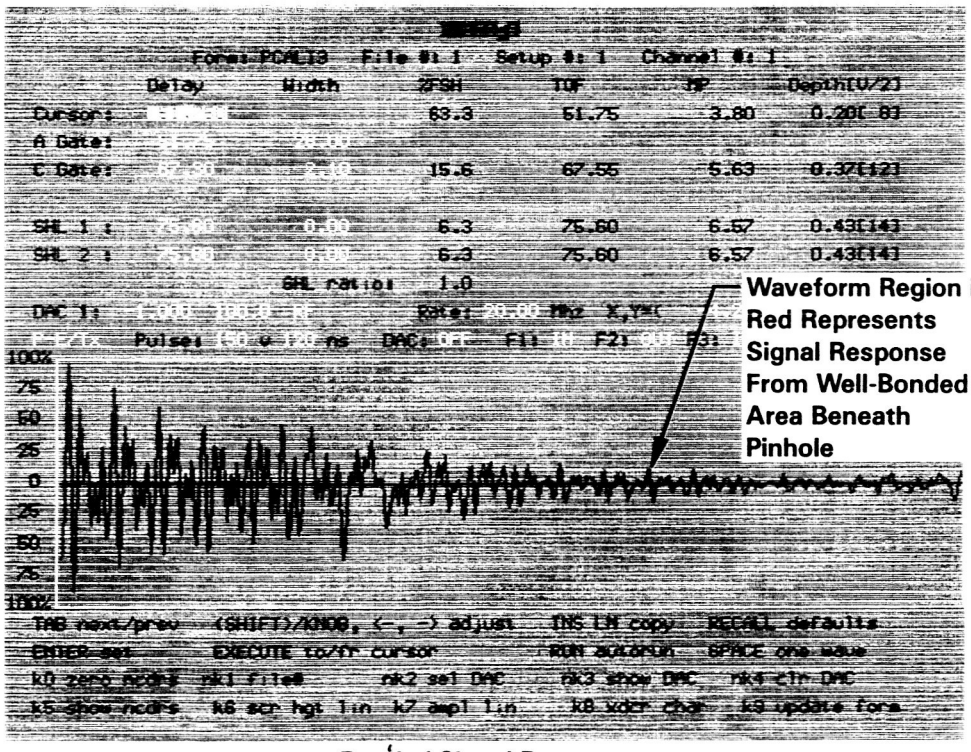


Bonded Signal Response

Figure 13. Calibration-out Sequence — Scan Run No. 2

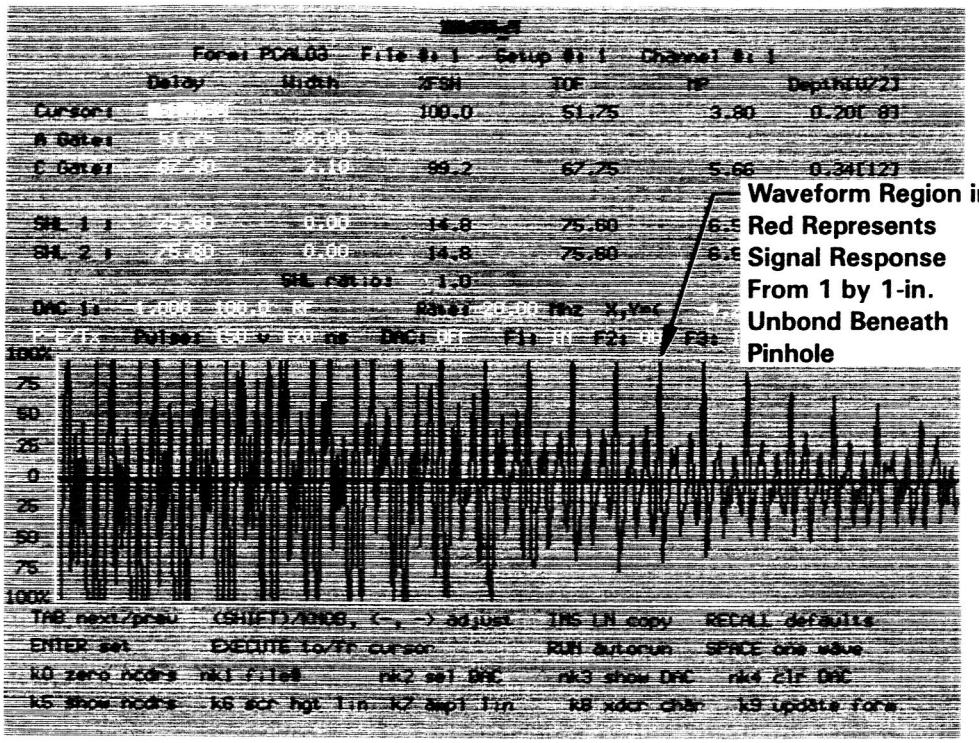


Unbond Signal Response

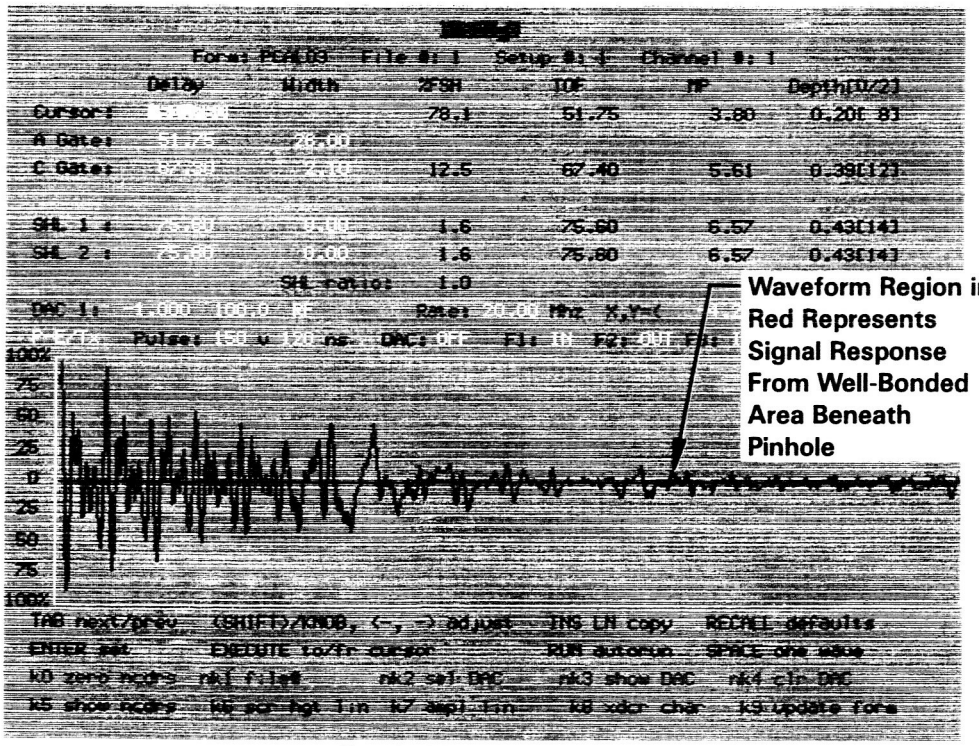


Bonded Signal Response

Figure 14. Calibration-in Sequence—Scan Run No. 3

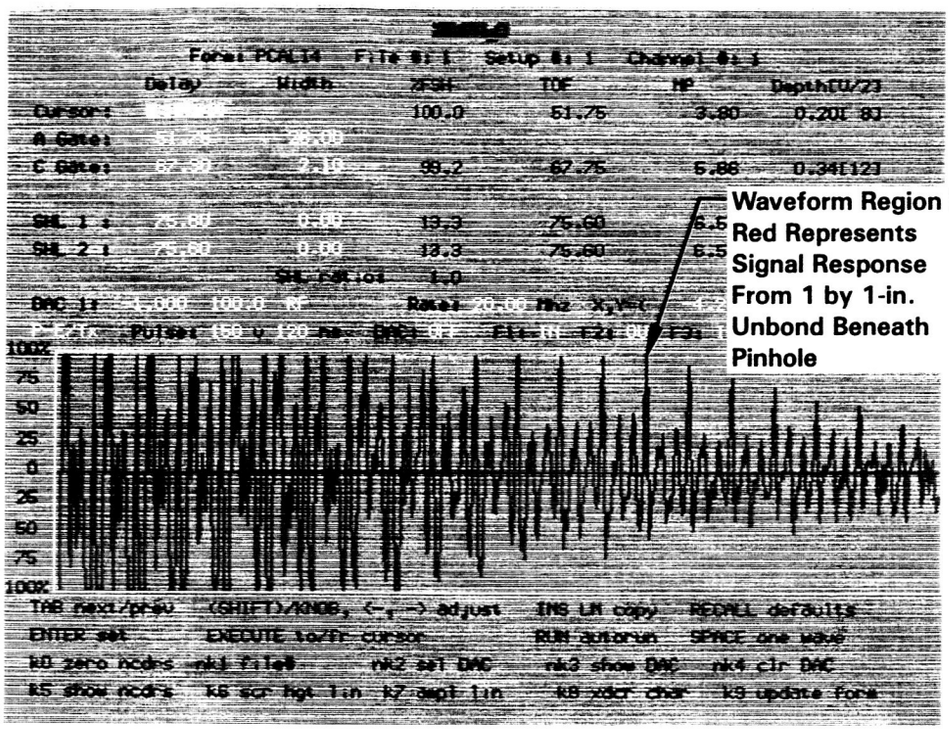


Unbond Signal Response

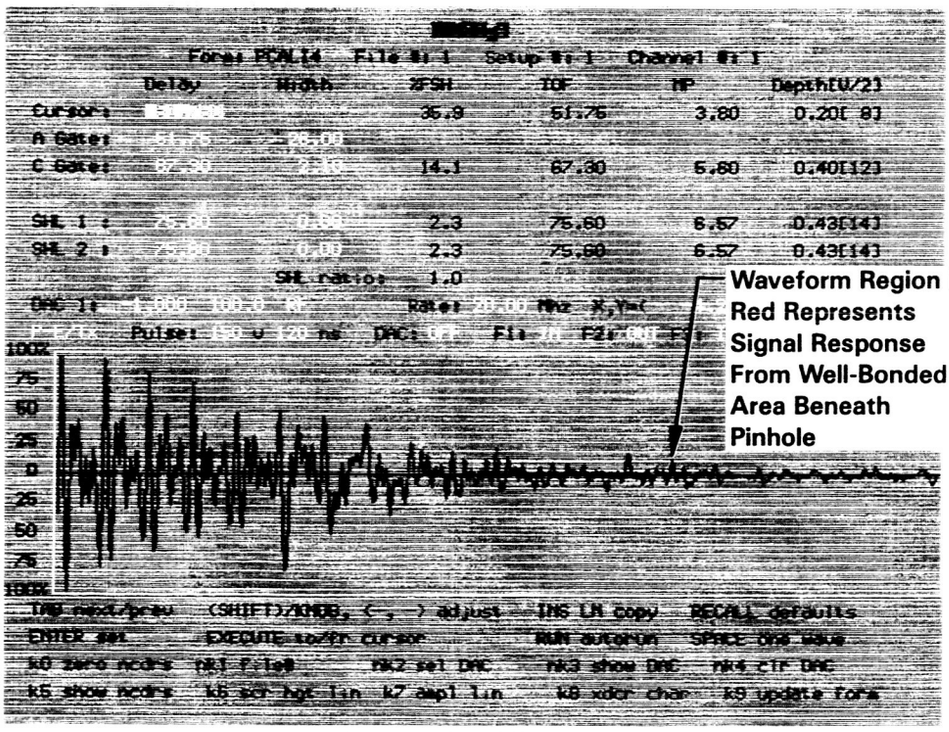


Bonded Signal Response

Figure 15. Calibration-out Sequence — Scan Run No. 3

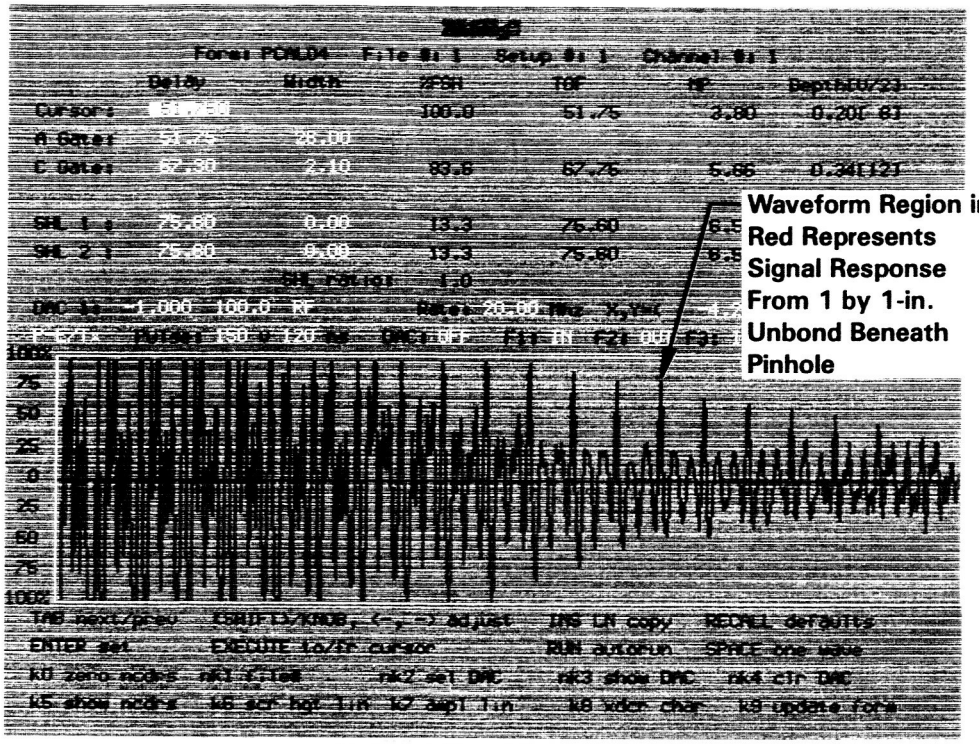


Unbond Signal Response

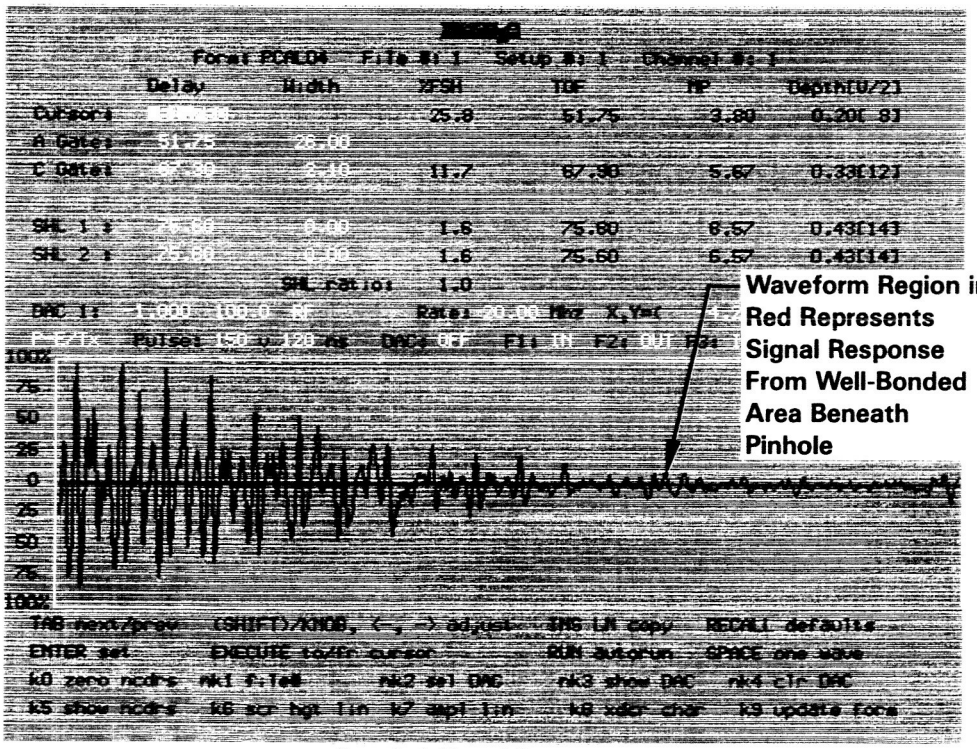


Bonded Signal Response

Figure 16. Calibration-in Sequence—Scan Run No. 4

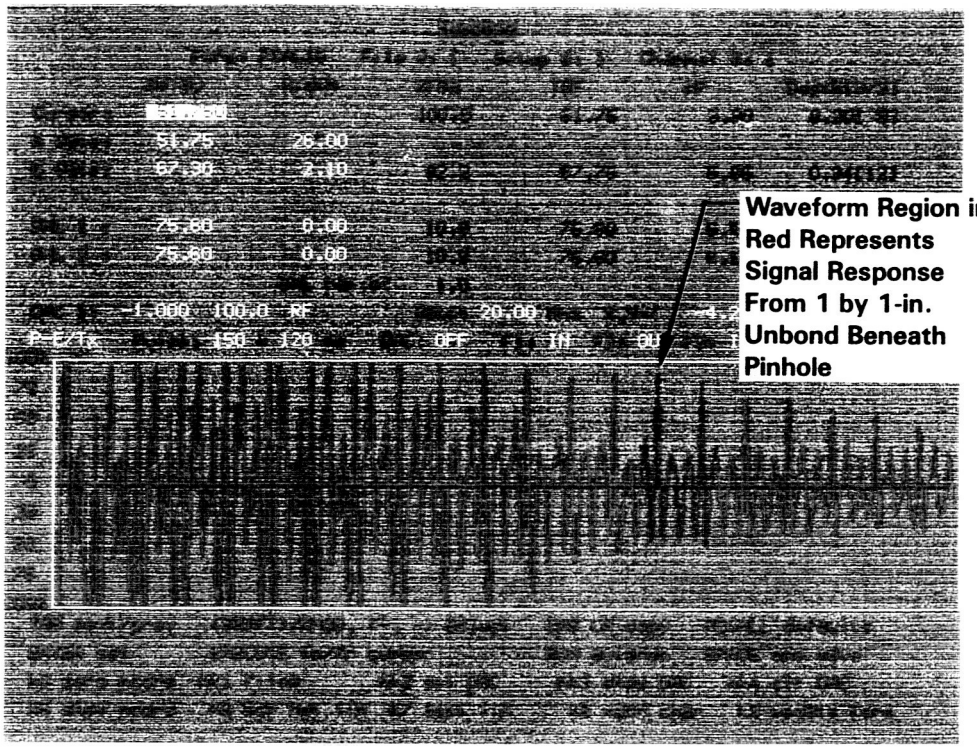


Unbond Signal Response

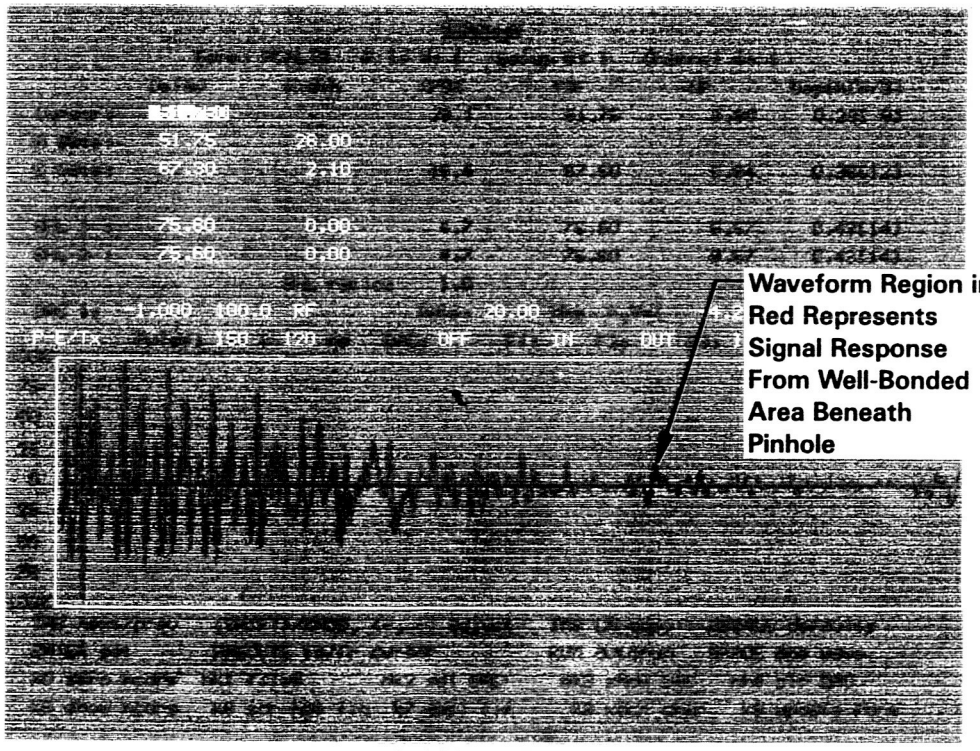


Bonded Signal Response

Figure 17. Calibration-out Sequence — Scan Run No. 4

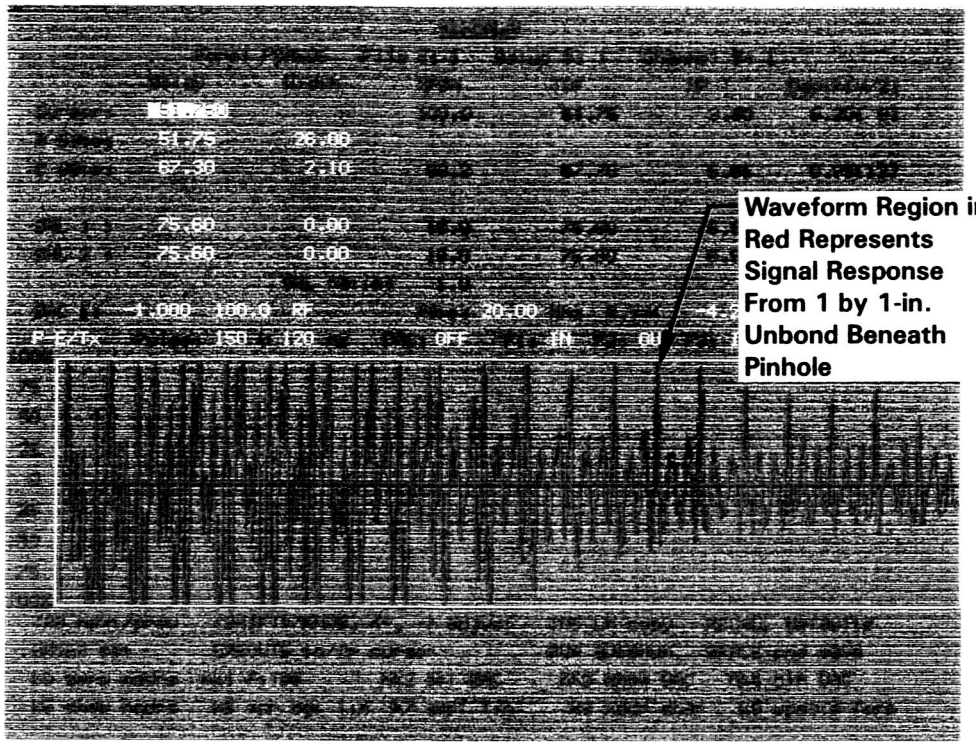


Unbond Signal Response

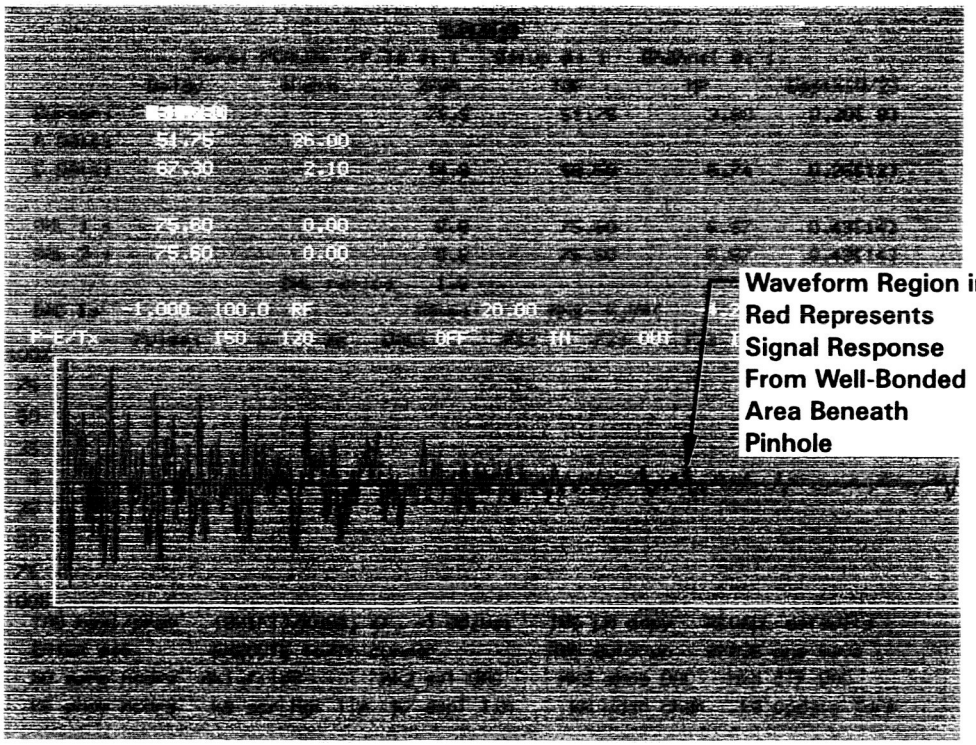


Bonded Signal Response

Figure 18. Calibration-in Sequence — Scan Run No. 5



Unbond Signal Response



Bonded Signal Response

Figure 19. Calibration-out Sequence — Scan Run No. 5

7

APPLICABLE DOCUMENTS

Document No.	Title
CPW1-3600	Prime Equipment Contract End Item (CEI) Detail Specifications
CDW2-3452	Performance, Design, and Verification Requirements Case-to-Insulation Bondline Inspection Kit, Ultrasonic Model Designator, C77-0479
CTP-0087	Qualification Plan for the Ultrasonic Inspection of the RSRM Field Joint Pinhole Case/Insulation Bondline Utilizing the MTI Ultrasonic RSRM Bondline Inspection System
CTP-0100	Qualification Test Plan for the Generic System Components of the MTI Ultrasonic RSRM Bondline Inspection System (URBIS)
NHB 6000.1	NASA Requirements for Packaging, Handling, and Transportation (for aeronautical and space systems, equipment, and associated components)
TWR-18894	Generic System Components of the RSRM Case-to-Insulation Bondline Inspection System Final Test Report
Military Standard	
MIL-STD-45662	Calibration System Requirements
Drawing No.	
2U129702	NDE Calibration Kit, SRM
2U129431	SRM PLI/Case UT Inspection Tool Arrangement

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